Automated furrow irrigation – economic case study, Burdekin region

Grower: Willy Lucas

The NQ Dry Tropics Project Catalyst provides an opportunity for sugarcane growers to work closely with technical specialists to examine innovative and aspirational practices that may enhance profitability, whilst reducing nutrient and pesticide losses from Burdekin farms and improving water quality entering the Great Barrier Reef. Moreover, it facilitates the communication of trial results to other growers, serving as a catalyst to sustainable farming.

This case study examines a cane block on Willy Lucas's farm that has recently been levelled and split into two 13-hectare blocks to compare the profitability of his conventional furrow irrigation system with an improved system using telemetry and automation (T & A). In particular, the costs to install automation are explored along with the differences in irrigating costs. Drawing on these costs, the study investigates if the investment into automation is profitable and considers how improvements in cane yield influence profitability.

Project Catalyst is a pioneering partnership funded by the Coca-Cola Foundation, through the World Wide Fund for Nature, and delivered in partnership with the Department of Agriculture and Fisheries, Farmacist, Burdekin Productivity Services and the Burdekin Bowen Integrated Floodplain Management Advisory Committee Inc.

Key findings:

- Installation costs estimated at $9,900 for the 13-hectare site
- Irrigating costs decreased by $5,388 (over 13-hectare site) mainly due to reduced electricity and labour requirements and electricity tariff savings
- Based on the outlined assumptions, the analysis indicates that:
  - The investment into automation is likely to be profitable with an annualised benefit of almost $3,000 a year
  - Recovery of capital outlay should occur in just over two years

Conventional furrow irrigation

Furrow irrigators spend a considerable proportion of their time completing irrigation tasks. Moreover, due to difficulties associated with irrigation scheduling, it is often unrealistic to manually close valves or begin the next set at the precise moment that optimises water application efficiency[1] (WAE). This problem is accentuated at night when it becomes difficult to determine the progression of irrigation water down the drill as well as becoming impractical for farmers to continuously monitor and control their irrigation systems late at night. Consequently, furrow irrigators schedule irrigation tasks that optimise the efficiency of the whole farming system ahead of just irrigation efficiency. A study by Holden and Mallon[2] (1997) established that irrigation application efficiencies in the Burdekin Delta varied between 13 and 70 per cent.

Image 1: Automated valve assembly

Source: Farmacist, 2015

[1] Water application efficiency refers to the amount of water stored in the root zone that is available to meet crop growing needs in relation to the volume of water applied to the field.

[2] Holden, J. R., & Mallon, K.M. (1997). *Land and Water Resources Research and Development Corporation Project BSE2 - Increasing irrigation efficiencies in the Australian sugar industry.* Burdekin: Bureau of Sugar Experiment Stations.

Telemetry and automation

The use of T & A enables irrigators to monitor their irrigation systems and maintain continuous management over irrigation events. Telemetry allows growers to communicate with their irrigation systems remotely, while automation enables them to control particular operations such as opening and closing valves and stopping pumps. Additionally, growers are able to monitor field status, which improves their ability to make decisions in real time.

These benefits permit farmers to reduce the number of visits they need to make to the paddock, saving vehicle running expenses and labour costs. Furthermore, T & A may help to improve irrigation cut-off times and water in-flow rates, thus improving WAE. Increasing WAE decreases runoff, deep drainage and/or waterlogging, which limits the quantity of pollutants leaving farms. Also, there is potential for cane yield improvements from less pooling of water, reduced loss of nutrients **(**via water losses**)** and less risk of under-watering. See Attard[3] (2014) for a comprehensive review of irrigation automation in the Burdekin.

Site description & trial design

The furrow irrigation system on Willy's farm is labour intensive. To offset some of the workload, Willy would like to fully automate the irrigation system and hence his decision to trial T & A with help from Project Catalyst. He also envisages a number of other benefits including a reduction in deep drainage, electricity cost savings from lower energy usage and the potential to take more advantage of low tariff periods.

Farmacist teamed up with other technical specialists in 2014 to try and develop a cost effective system that is tailored to suit Burdekin sugarcane farms. Farmacist established the trial site in 2015 after developing some of the equipment necessary for the trial. The site is a 26-hectare cane block that has been recently levelled and split into two 13-hectare blocks; one block with T & A and one without the technology, side by side. Table 1 provides a summary of the characteristics of the trial blocks, while Figure 1 provides a basic illustration of the site. Both blocks were planted with Q240 in 2014.

Table 1: Characteristics of trial site

Element	Description
Location:	Osborne (near Home Hill)
Soil type:	Clay loam
Water supply:	Bore
Crop stage:	First ratoon (harvested 2016)

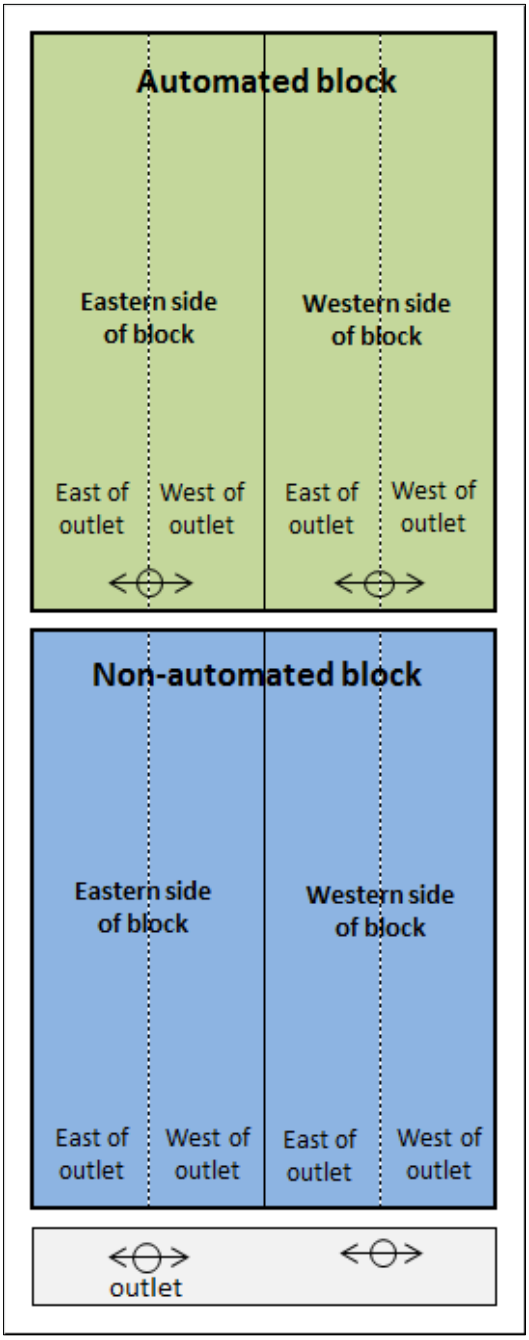

Figure 1: Diagram of trial site

[3] Attard, S. (2014) Automating furrow irrigation in the Burdekin sugarcane industry. NQ Dry Tropics, Townsville.

Methodology

Four key questions are examined in this study. The first question explores the costs to install automation, while the second compares the irrigating costs of the conventional system with the automated system. The main cost differences include electricity, labour, vehicle operating expenses and irrigation repairs and maintenance (R & M) expenses.

Image 2: Valve controller

Source: Farmacist, 2015

Drawing on the installation costs as well as the differences in irrigation costs, the third research question investigates if the investment into automation is likely to be profitable by completing an investment analysis. As no production data has yet been collected from the trial, revenues are calculated using past block production data to approximate future ratoon yields. Table 2 shows the production estimates; cane yield (TCH) and commercial cane sugar (CCS).

Table 2: Estimated production during ratoon crops

	TCH	CCS
1R	147	14.3
2R	138	14.5
3R	119	14.4

	TCH	CCS
4R	115	13.9
5R	101	14.7

Uncertainty exists around the influence automation will have on crop yields. For example, using T & A helps to improve the accuracy of water applications (less over/under watering) by enabling users to apply a quantity of water that is closer to what the crop needs to maximise yield potential. To incorporate this factor, the fourth question examines how potential cane yield improvements would influence the profitability of an investment into T & A.

The Farm Economic Analysis Tool (FEAT) was used to evaluate the revenues and costs of each treatment. From these results, the gross margin[4] of each treatment is compared. The analysis uses a discount rate of 7 per cent and the five-year average sugar price of $430/t. Input prices were collected from local suppliers and labour has been costed at $30/hour.

Installation costs

Table 3 lists the estimated cost for each piece of equipment required for the trial site, while Figure 2 shows the relative spend on the componentry. The largest cost components of the investment include the pump controllers as well as the costs to automate the valves and the end of row sensors. Overall, the total investment needed for the 13.3-hectare trial site is approximately $10,000 (or $746/ha).

Table 3: Breakdown of investment (excluding GST)

Item		Qty.	Subtotal
Base station		1	$300
Automated valves (includes circuit boards, battery units, actuators and solar panels)		2	$3,000
Pump controllers		4	$4000
End-of-row water sensors		2	$1,500
Labour to install system (hrs)		20	$600
Electrician		1	$500
Total	*$746/ha*		**$9,900**

Notably, Willy has installed pump controllers on four pumps as in the past he has used combinations of up to four pumps when irrigating double irrigation sets (110 rows) on these blocks. As Willy actually uses these four pumps to irrigate around 50-hectares (he uses nine pumps in total

[4] The gross margin is a measure of profitability and is calculated by subtracting variable growing expenses (e.g. cartage and fertiliser) from revenue.

across his farm), extending automation across his whole 186-hectare farm would decrease the per hectare cost of the system due to improvements in equipment utilisation.

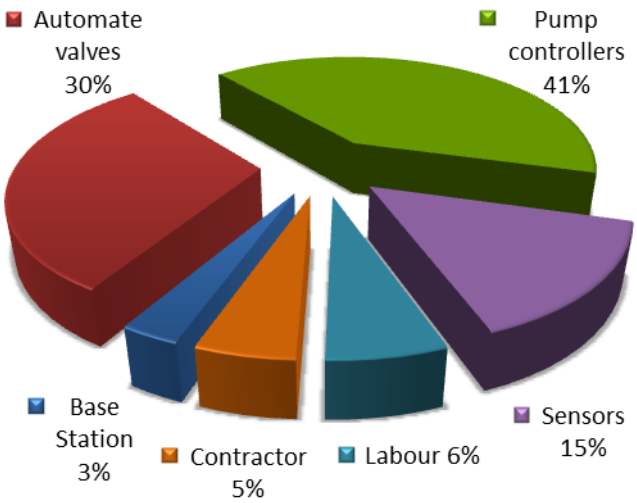

Figure 2: Breakdown of investment (%)

The projected life of the equipment is to the end of the current crop cycle, which Willy expects to be fifth ratoon (or five years). Consequently, the analysis assumes a five year investment life. All other expenditure on the T & A system over its life becomes encapsulated within irrigation R & M. Table 4 lists the forecasted annual R & M costs required to maintain the systems efficient operation.

Table 4: Forecasted annual R & M costs ($)

Item	Qty.	Subtotal
Replacement Antennas	2	$20
Batteries (AA)	4	$10
Labour – to install antennas & general maintenance (hrs)	3	$90
Total		**$120**

Irrigation expenses

The main irrigating cost differences between Willy's conventional and automated furrow irrigation systems include:

- Electricity costs (electric pumps)
- Labour costs
- Vehicle running expenses - fuel, oil, R & M
- Irrigation R & M expenses

By shifting to automation, Willy is able to shift from a 12-hour irrigation set regime, where he is irrigating 110 rows (double irrigation set) over 12-hours using four pumps, to an improved system that better matches in-flow rates with soil infiltration rates. For the automated system, he irrigates 55 rows (single irrigation set) using three pumps and gets the water down in 5.5 to 6 hours. Using automation, he is able to reduce his electricity use by an estimated 26 per cent, consuming 7,000 less kilowatt hours annually over the 13-hectare block.

In addition, automation enables Willy to save money by exploiting lower electricity tariffs available on weekends without disrupting his lifestyle. As such, Willy is planning to switch to tariff 62 and transfer up to 14 hours per week of irrigating at a higher tariff to a lower tariff. However, it may be unlikely that Willy will be able to transfer the whole 14 hours every single week for every pump (due to dry down, post-harvest scheduling, rain, etc.). As a result, the analysis assumes that he can transfer two-thirds of the total available (~9 hrs/wk) [5]. Automation should also decrease the wear and tear on irrigation infrastructure by reducing the quantity of water being pumped[6].

Importantly, these improvements do not come at the cost of interfering with other farming duties or his lifestyle. In fact, automation allows Willy to reduce the time he spends on irrigation tasks. Based on irrigation data collected during the trial, Willy found that he could reduce the number of times he visited the block when irrigating. For instance, he generally visits a block between 3 to 5 times (i.e. checking the progression of irrigations and turning pumps on/off or switching sets).

Willy recorded that each round trip to a block would take an average of 20 minutes, which depended

[5] Electricity usage by Willy's conventional system was determined from Ergon invoices. Electricity costs for the T & A system are based on the current system's costs but deduct the amounts derived from the reduced pumping time and tariff savings.

[6] Total R & M costs for the current irrigation system were calculated from past spending on pumps, motors, fluming and cups as well as the labour costs involved with servicing and repairing. The total costs were divided by a proxy for the quantity of water applied ($/ML) and then multiplied by the estimated application rate per hectare ($/ha). These costs for the T & A system were calculated using the same method but vary due to lower water application rates and the additional costs necessary for the extra equipment.

on where he was (e.g. in the tractor, on his other farm) and what means he used to get there (ute, four-wheeler, tractor, etc.). By using automation, he can generally visit the block just once during an irrigation set, or in the beginning twice to confirm correct operation. Over a season these time savings add up with a total annual saving of 57 hours across the 13-hectare trial site, which is around a 40 per cent reduction in irrigation labour demand[7]. Furthermore, less visits means he benefits from lower vehicle use expenses; fuel, oil, R & M.

Figure 3 compares the irrigation expenses over the 13-hectare sites for both systems. The total annual irrigation costs are located near the bottom of the chart. A comparison of the systems highlights that considerable savings in irrigation expenses can be made from using automation ($5,388). The largest cost savings are generated by reduced electricity usage and tariff savings, followed by labour savings.

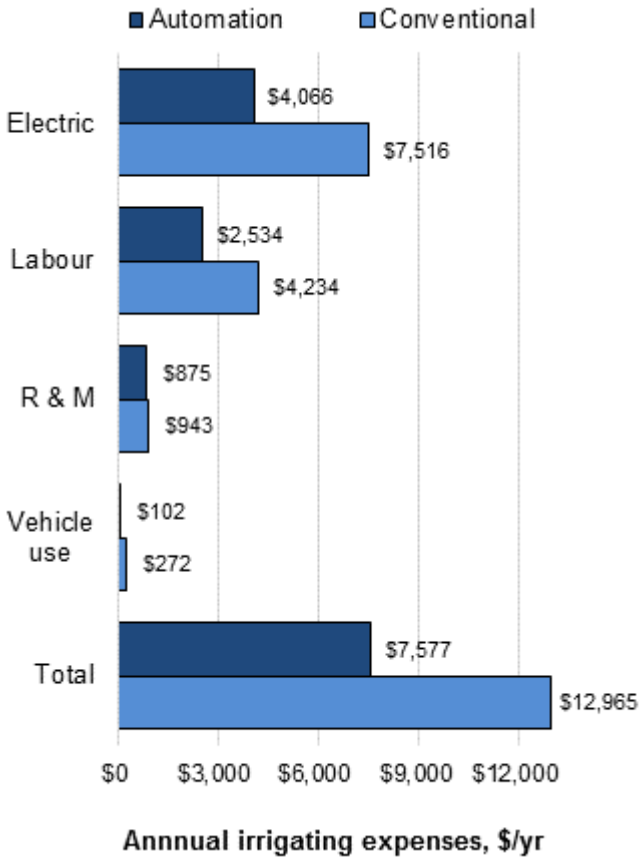

Figure 3: Annual irrigation costs for 13-hectare site

[7] Total irrigation labour hours were calculated from the amount of time Willy spends in the paddock completing irrigation tasks.

Investment analysis

While the automated system has relatively lower irrigating costs, are the savings large enough to recover the initial capital outlay into T & A, assuming that both the conventional and automated systems harvest the same cane and sugar yields? To put these cost savings into perspective, Table 5 outlines the results of an investment analysis.

Based on the previously defined assumptions, the results show a positive net present value[8] of over $12,000, indicating a profitable investment, with an annualised benefit of almost $3,000 a year and annual rate of return of 46 per cent. The analysis also found that the capital outlay should be fully recovered just after the second year. Interestingly, Willy could potentially spend up to ~$22,000 on installing the system before the investment becomes unviable.

Table 5: Investment summary

Net present value	$12,193
Annualised equivalent benefit[9]	$2,974
Internal rate of return[10]	46%
Discounted payback period[11]	2.03 yrs
Breakeven capital outlay	$22,093

Cane yield improvement

Figure 4 investigates how improved cane yields (relative to conventional furrow irrigation) would influence the annualised benefit from an investment into T & A, assuming that CCS remains constant. The results indicate that if automation can help to boost cane yield by 5 TCH during every

[8] The net present value of an investment is the sum of all cash flows (discounted to present value) that accrue to a grower over the life of an investment minus the initial capital outlay. It takes into account both the installation costs for T & A as well as differences in irrigating costs. A positive value indicates an economically acceptable investment on the basis that the present value of the cost savings is greater than the initial capital outlay.
[9] The annualised equivalent benefit is a transformation of an investment's net present value. It identifies the annual monetary benefit that would accrue to a grower over the life of an investment.
[10] The rate of return refers to the amount of extra money earned annually as a percentage of the capital outlay.
[11] The discounted payback period refers to the period of time required to recover the initial capital expenditure.

ratoon crop, then Willy could anticipate a comparative improvement in annual return of $5,162 over the 13-hectare site, which is $2,000 higher than without a yield improvement.

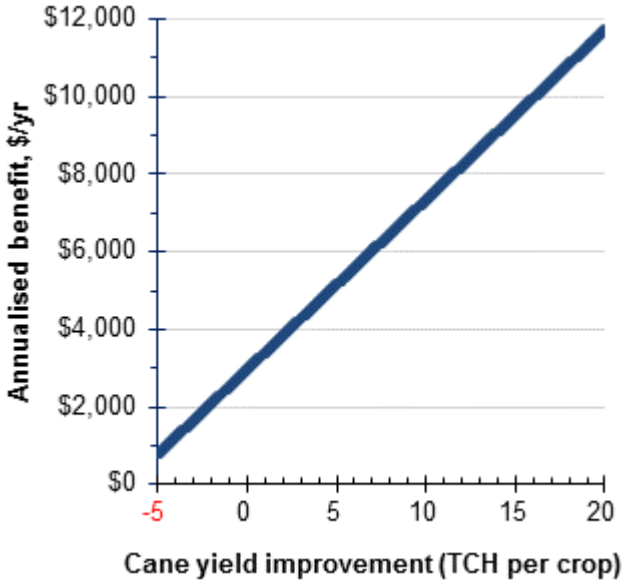

Figure 4: Sensitivity of annualised benefit to improvements in cane yield (TCH)

Conclusion

Using T & A enables irrigators to control particular operations including turning pumps on and off and opening and closing valves, which may reduce the labour intensity of furrow irrigation and improve water use efficiency. This case study examined a cane block on Willy Lucas's farm that has recently been levelled and split into two 13-hectare blocks to compare the profitability of his conventional furrow irrigation system with an improved automated system. In particular, the costs to install automation were explored along with the differences in irrigating costs. Drawing on these costs, the study investigated the profitability of the investment into automation and examines how cane yield improvements influence profitability.

The analysis identified that using T & A generated irrigation cost savings driven by lower electricity and labour requirements as well as electricity tariff savings. Based on the outlined assumptions, the results indicate that Willy's investment into automation is profitable with an annualised benefit of almost $3,000 a year, and would recover the capital outlay in just over two years. The analysis also found that Willy could potentially spend up to ~$22,000 on installing the system before the investment becomes unviable. Furthermore, cane yield improvements were found to considerably improve annual investment returns.

As the performance of the T & A system becomes better known over time, greater certainty can be placed around the assumptions used for the analysis.

Image 3: End of row water sensor

Source: Farmacist, 2015

Acknowledgements

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Citation

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